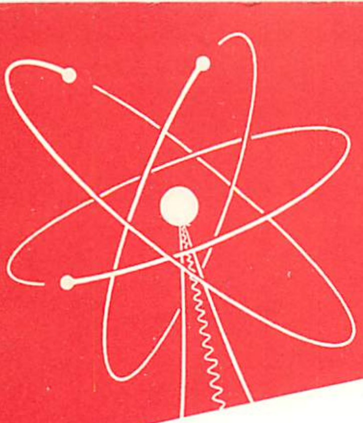

SOUND CHANNELS

Lesson T2C-8A

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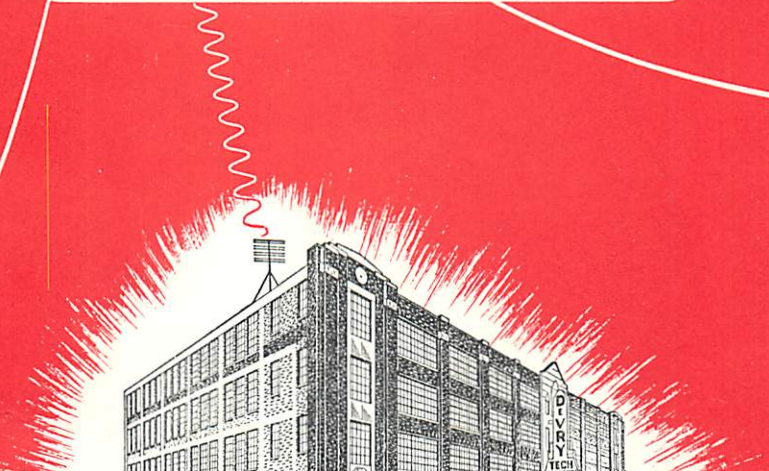

DeVRY Technical Institute

4141 W. Belmont Ave., Chicago 41, Illinois
Formerly DeFOREST'S TRAINING, INC.

T2C-8A

SOUND CHANNEL

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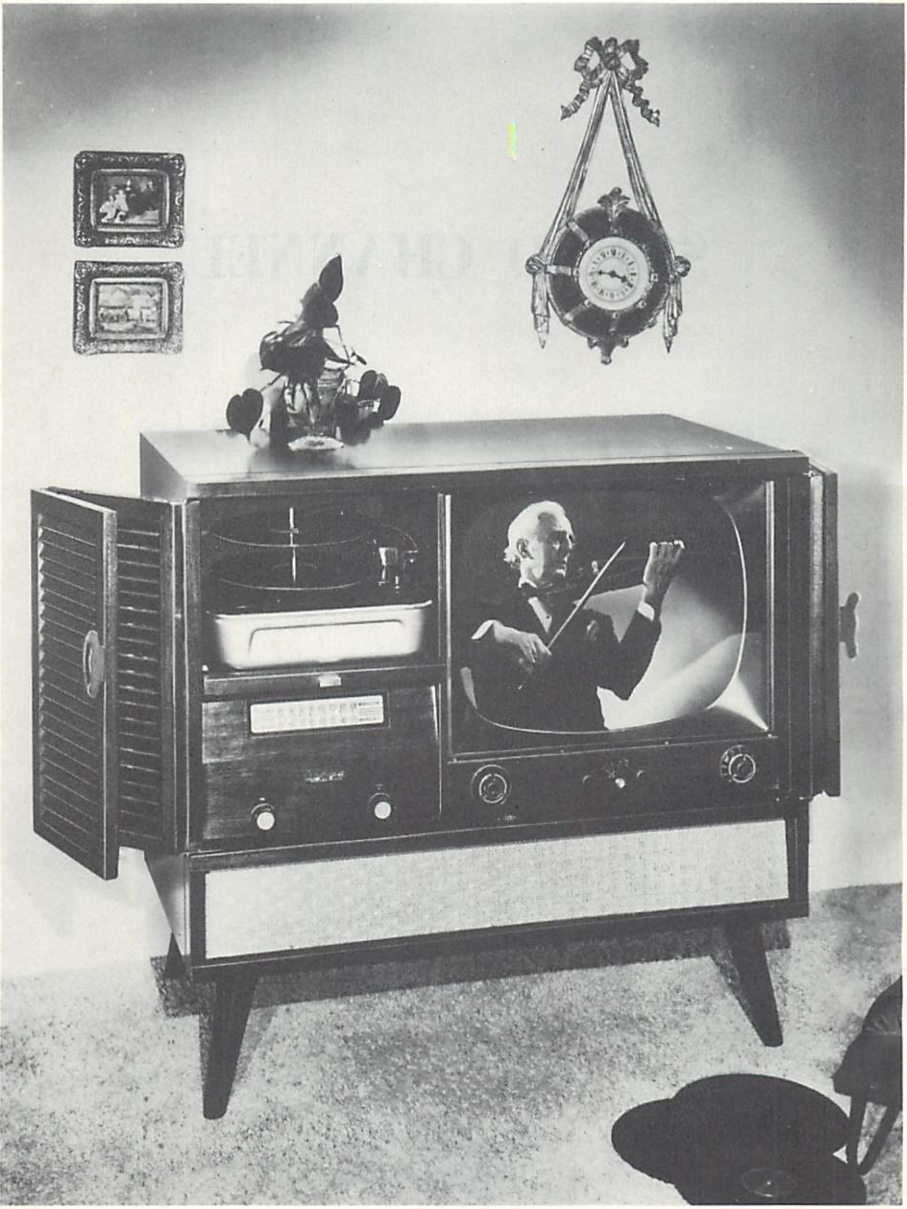

A combination instrument which includes a television receiver, a radio receiver with choice of AM or FM, and an automatic record changer phonograph.

Courtesy of Andrea Radio Corp.

SOUND CHANNEL

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If there is one thing more than any other that characterizes the average American, it is his eagerness to learn almost anything at almost any age.

—H. V. Kaltenborn

SOUND CHANNEL

The television receiver can be considered a combination of two radio receivers. When tuned to any given channel, the receiver accepts two carrier waves, one modulated with the picture information, the other with the sound signal. The respective carriers are converted to intermediate frequencies, amplified, and demodulated to provide the video and audio signals. Finally, one of the two "radio receivers" converts the video signals into a visible image, while the other converts the audio signals into sound.

After the picture and sound information are separated in the television receiver, the sound i-f carrier is applied to a series of stages called the SOUND CHANNEL. This section of the receiver corresponds to an FM radio receiver, minus the r-f stages. That is, the television receiver sound channel contains an i-f amplifier, a detector, and an audio amplifier and speaker. The details of the operations of these types of circuits have been explained previously. This lesson reviews the fundamental principles involved, and describes typical sound channel circuits employed in television receivers.

SEPARATING THE PICTURE AND SOUND SIGNALS

A block diagram of a television receiver is shown in Figure 1. The four upper blocks represent the sound channel, and the remaining blocks indicate all of the other receiver stages which carry the picture and sound signals. Picked up by the antenna, the picture and sound carriers are amplified by the r-f stage, then converted to corresponding intermediate frequencies by the mixer stage. Both sound and picture i-f carriers and their sidebands are amplified in the picture i-f amplifiers, and then applied to the video detector.

The sound and video carriers differ in frequency by 4.5mc. This frequency difference is established at the transmitter and it is not changed by the mixer in the r-f section of the receiver. Therefore the two i-f carriers are still 4.5 mc apart in frequency when they reach the video detector.

At the video detector, a second mixing or heterodyning action takes place. The video i-f carrier can be thought of as the signal from a second local oscillator, and when it heterodynes with the i-f sound signal, a difference frequency of 4.5 mc is produced. This becomes the new sound i-f #1 carrier and is diverted to the sound channel, while the video is passed on to the picture tube.

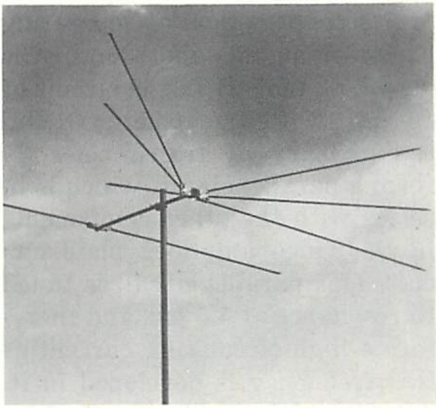
To prevent the sound carrier from being strongly amplitude modulated by heterodyning with the video carrier, the magnitude of the sound i-f is kept low com-

#2

pared to the picture i-f. Whenever two signals are mixed in a detector circuit, if one of the two voltages is kept small, the amplitude of the beat frequency voltage is little affected by the larger voltage. Hence, the magnitude of the video signal entering the detector should be at least ten times that of the sound signal. This results in a sound i-f signal which is chiefly frequency modulated, for it retains the original frequency deviations accomplished at the transmitter. The small AM remaining in the sound i-f signal due to heterodyning does not normally impair reception, since limiting action in the sound channel removes it.

In some receivers, the 4.5 mc sound i-f is diverted to the sound section following the video detector, while the video is further amplified and impressed upon the picture tube. In other receivers, both signals are amplified by the video amplifier before they are separated. The amplification is accomplished by making the video amplifier response broad enough to reach up slightly above 4.5 mc.

It was pointed out that the sound i-f voltage at the detector input is kept relatively low to minimize amplitude modulation. Another reason for keeping it relatively low is that the problem of keeping the sound out of the picture is minimized. However, usually this problem is not difficult since the video frequencies vary from 30 cycles to 4 megacycles while the sound i-f is 4.5 mc.



The television receiving antenna picks up both the picture and sound r-f carriers.
Courtesy Channel Master Corp.

One method of separating the 4.5 mc sound i-f carrier from the video signal is shown at the extreme left in Figure 11. Here, both signals are coupled through C_2 and impressed on the tuned circuit L_3C_3. This circuit is tuned to resonance at 4.5 mc, and therefore has high impedance at this frequency. Since the voltage across a parallel tuned circuit is maximum at the resonant frequency, a high voltage at 4.5 mc appears between the grid of V_2 and ground. However, the impedance of L_3C_3 is low for the video frequency signals. Thus, the sound i-f signal is passed on to the grid of the sound i-f amplifier, but the video signals do not get through. As indicated in the Figure, the video signals are taken from the junction between L_1 and L_2 and applied to the picture tube.

A second method of separating the video signals and sound i-f is shown at the left in the circuit of Figure 12. Here, capacitor C_1 and the primary of transformer T_1 form a parallel circuit which is in series with the other components in the video amplifier plate circuit. This parallel circuit is tuned to resonance at 4.5 mc, and therefore a high circulating current at this frequency is developed in it. The resulting flux transfers energy to the secondary at this frequency. Thus, the 4.5 mc i-f is coupled to the grid circuit of V_2, the first tube in the sound channel. Again, the tuned circuit has low impedance at the video frequencies. As indicated, the video signals are taken from the slider on R_2 to be applied to the input of the picture tube.

Older models of television receivers may be encountered in service work which are designed along the general plan shown in Figure 2. In these receivers, the sound i-f produced by the mixer is separated from the picture i-f at some point ahead of the video detector. The separation may occur at the mixer output, or in one of the i-f amplifier stages following the mixer, as shown in the Figure. Taken from this section of the receiver, the sound i-f may be 21.6 mc, and is applied to the sound channel which contains two or more sound i-f amplifiers. Because the i-f signals are separated at a relatively early point in the receiver, and are not mixed in the video detector, this type is known as a DUAL CHANNEL receiver. The arrangement used in present day receivers, shown in Figure 1, is termed the INTERCARRIER system.

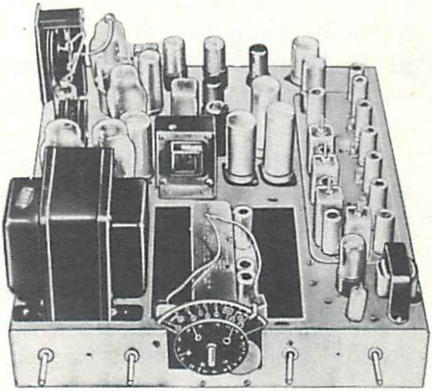
In both the intercarrier and dual channel systems, the picture i-f amplifiers have broad response, but the sound i-f amplifiers are tuned relatively sharp. Thus, a slight frequency drift of the high frequency oscillator does not affect picture quality greatly in either receiver, but causes distortion of the reproduced sound in the dual channel receiver. This result occurs because, when the oscillator frequency is off, the i-fs produced are higher or lower than the specified frequencies. With the sound channel circuits of Figure 2 tuned to a center frequency of 21.6 mc for example, the detector produces a distorted audio signal when the i-f signal is higher or lower than this frequency.

However, when the oscillator drifts in the intercarrier type receiver, both the picture and sound i-f signals increase or decrease the same amount. Thus, the frequency difference between them is always 4.5 mc, as established at the transmitter. Therefore, regardless of their exact frequencies at the mixer output, the two i-f signals beat in the video detector to produce the second sound i-f of exactly 4.5 mc. Applied to the sound channel, Figure 1, this 4.5 mc carrier is always at the center frequency of the tuned circuits. Therefore, the sound output is not distorted in the intercarrier receiver when the oscillator frequency drifts slightly. Before going ahead with the characteristics of the sound channel, a brief review of some of the fundamental principles of an FM receiver will be helpful.

PRE-EMPHASIS

The higher frequency components of speech and music normally have less amplitude than the lower frequency components. This means that if the noise level is the same, regardless of the audio frequency, the signal-to-noise ratio is lower for a high frequency audio voltage than for one of low frequency. Also, if noise inherent in the transmitter is greater at the higher audio frequencies, the relative signal-to-noise ratio is still lower. If nothing is done to improve this condition, the quality of the higher frequency audio reproduction at the receiver is impaired.

At the transmitter, steps are taken to improve the high frequency signal-to-noise ratio by accentuating the high frequency components of the audio modulating voltage. The FCC has stated that PRE-EMPHASIS SHALL BE EMPLOYED IN ACCORDANCE WITH THE IMPEDANCE-FREQUENCY CHARACTERISTIC OF A SERIES INDUCTANCE-RESISTANCE NETWORK HAVING A TIME CONSTANT OF 75 MICROSECONDS.



Television receiver chassis on which the sound and picture i-f amplifiers are mounted on a removable panel shown at the right. The a-f amplifier tubes and output transformer are at front right.

Courtesy Television Assembly Co.

As an example to illustrate just what this statement means, assume that the audio voltage is impressed upon terminals (1) and (2) of the circuit of a 75,000 ohm resistor in series with an inductor as illustrated in Figure 3. If the correct inductance is chosen, the audio modulating voltage taken from terminals (3) and (4) has the higher frequencies accentuated as required.

The correct inductance, L, will be such that the time constant, L/R, is 75 microseconds. If $L/R = 75$ microseconds, or .000075 second, then $L = R \times .000075 = 75{,}000 \times .000075 = 5.625$ henrys. The two series elements of R and L serve as a voltage divider, and if the higher frequencies are accentuated, the voltage across L must be higher at the high frequencies than at the low for a given input voltage at terminals (1) and (2).

The manner in which the output voltage varies with frequency is shown by the solid curve of Figure 4. At 50 cycles per second the output voltage is a little less than 2.5% of the input voltage. At 200 cps it increases to nearly 10%, after which it rises rapidly, but starts flattening out below 4000 cps, and at 15,000 cps, it is slightly below 100% of the impressed voltage.

The use of a 75,000 ohm resistor and a 5.625 henry inductor has no particular significance insofar as practical values for pre-emphasis filters are concerned. It is the relative values of resistance and inductance which must be chosen correctly to give the desired 75 microsecond time constant.

DE-EMPHASIS

The transmitted sound signal has been purposely distorted by the pre-emphasis filter network and unless this distortion is removed at the receiver, the sound #6 from the loudspeaker is not natural. After the frequency deviations due to modulation have been converted to audio amplitude variations by the sound detector, the high audio frequencies must be de-emphasized or attenuated. Since this action also reduces the higher frequency noise voltages, it provides the desired over-all noise reduction.

A receiver de-emphasis filter can be designed to use either a resistor and an inductor, or a resistor and a capacitor. As a capacitor is lighter, requires less space, and in most cases is less expensive than the inductor, the capacitor is used most commonly.

A de-emphasis filter consisting of a resistor and a capacitor in series is shown in Figure 5. In actual practice, the time constant, RC, is made approximately equal to the time constant L/R of the transmitter pre-emphasis filter, so that the higher audio frequencies are attenuated to the correct proportional level that exists at the transmitter microphone.

The reactance of capacitor C decreases with an increase in frequency, while the resistance of R remains constant. Therefore, as the frequency of the input voltage is increased, a smaller percentage of the input voltage amplitude appears across capacitor C. This is just the reverse of the process in the transmitter, and the combined action of pre-emphasis and de-emphasis accomplishes an improvement in signal-to-noise ratio, yet leaves the audio output as a good reproduction of the audio input at the transmitter.

The miniature pentode type 6AU6 is employed often as the i-f amplifier in the sound channel. It is a sharp cutoff tube, and is used also as a limiter.

Courtesy Hytron Radio and Electronics Co.

When the time constant, RC, of the network shown in Figure 5 is 75 microseconds and the resistance of R is 75,000 ohms, the correct capacitance for C can be computed from the relation:

$$\text{Time Constant} = RC = .000075 \text{ second}$$

$$75{,}000 \times C = .000075$$

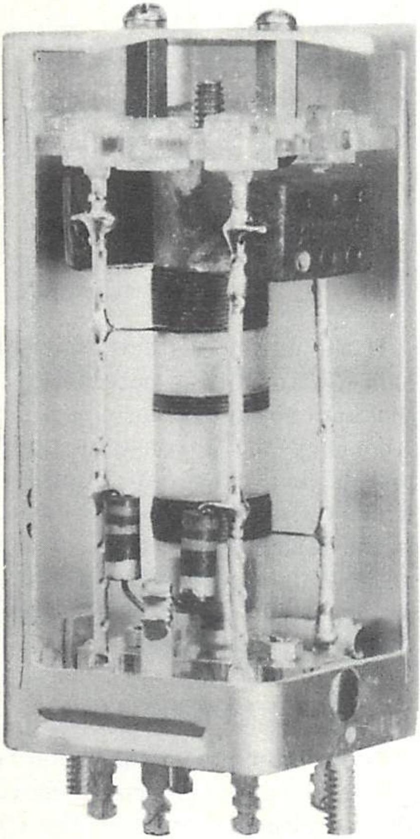
$$C = \frac{.000075}{75{,}000} = .000000001 \text{ farad}$$

$$\text{or } .001 \text{ microfarad.}$$

If the output voltage at terminals (3) and (4) in percentage of the input voltage is plotted against frequency for a constant input, the dashed curve of Figure 4, which is marked "de-emphasis," is the result. While this curve is not exactly the inverse of the pre-emphasis curve, it is close enough for practical purposes.

AUDIO DETECTORS

In an intercarrier television receiver, the audio detector removes the a-f information from the frequency modulated 4.5 mc i-f carrier. The detector output corresponds to the a-f signal produced by the microphone at the transmitter studio. To produce this desired signal, the audio detector develops in its output circuit an alternating voltage which is determined by the frequency variations of the i-f carrier applied to its input. At any given instant, the frequency of the developed output voltage corresponds to the rate at which the i-f carrier is changing frequency. The frequency change by the i-f carrier determines the instantaneous amplitude of the audio output.



Cut-a-way view of a ratio detector transformer. Notice the tertiary winding between the primary and secondary windings.

Courtesy National Co., Inc.

Present day television receivers employ either of two basically different types of detector circuits. One of these basic types is the discriminator, the other is the gated beam detector. The operations of both types have been explained in previous lessons. These detectors, especially the discriminators, have a number of variations, and the following explanations describe those circuits commonly employed in the sound channels of television receivers, along with a brief review of their operating principles.

Ratio Detector

The commonly used discriminator "types" are the ratio detector circuits of Figures 6 and 7. The circuit of Figure 6 is called a balanced ratio detector because the junction between R_1 and R_2 is grounded. The unbalanced ratio detector of Figure 7 has one end of the load resistor R_1 grounded.

In both the circuits of Figures 6 and 7, the transformer primary L_1 couples the i-f signal into L_2, L_3, and L_4. As L_3 and L_4 are the two halves of a single winding, the voltage applied by L_3 to V_1 is 180° out of phase with that applied by L_4 to V_2. The voltage across L_2 is applied to both diodes. Thus, each diode has two voltages applied to it. That is, E_{L_2} and E_{L_3} are applied to V_1, while E_{L_2} and E_{L_4} are applied to V_2.

In Figure 6, the V_1 electron flow is from the cathode to the plate, through L_3 and L_2 to the lower plate of C_3, out of the C_3 upper plate and to the lower plate of C_4, and out of the upper plate to the cathode of V_1. These pulses of diode current charge C_3 such that its lower plate is negative with respect to ground.

The V_2 electron flow is from the cathode to the plate to the upper plate of C_3, and from the lower plate through L_2 and L_4 to the cathode of V_2. These current pulses charge C_3 such that its lower plate is positive with respect to ground. Similar actions occur in the circuit of Figure 7. In this case, V_1 current pulses make the lower plate of C_3 positive, while the V_2 pulses make this plate negative with respect to ground. In both circuits, the two diodes tend to charge capacitor C_3 in opposite directions.

When the i-f carrier is at the 4.5 mc center frequency, E_{L_2} is exactly 90° out of phase with E_{L_3}, and also with E_{L_4}. Since E_{L_3} and E_{L_4} are 180° out of phase with each other, if E_{L_3} lags E_{L_2} by 90°, then E_{L_4} leads E_{L_2} by 90°. With these phase relationships, the vector sum of the voltages applied to V_1 is equal to the vector sum of those applied to V_2. The diode currents produced are equal also, and the average charge or voltage on C_3 is zero.

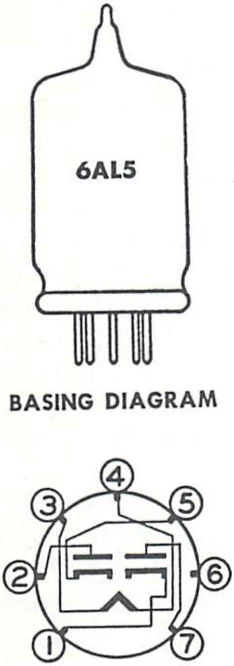
As the i-f signal swings above and below the center frequency, the phases of E_{L_3} and E_{L_4} shift relative to E_{L_2}, causing the vector sum of E_{L_3} and E_{L_2} to become alternately greater and less than the vector sum of E_{L_4} and E_{L_2}. As a result, the V_1 current alternately becomes greater and less than the V_2 current, causing the average voltage on C_3 to swing positive and negative, alternately, with respect to ground. These variations in E_{C_3} occur at the rate of the frequency swing of the i-f carrier, and the extent of the i-f deviation determines the magnitude of the voltage produced across C_3. Thus, E_{C_3} corresponds to the modulation, and, forming the audio signal, is coupled through resistor R_3 to the audio amplifier. In both circuits, R_3 and C_5 form the de-emphasis filter. Capacitor C_4 has relatively large capacitance, 4 to 10 microfarads, and becomes charged to the mean value of the peak voltage across the tuned circuit $L_3L_4C_2$.

#1

In Figure 6, the lower plate of C_4 is negative and the upper plate positive. Equal resistors R_1 and R_2 form a voltage divider across C_4. Thus, a voltage equal to one-half of E_{C_4} biases the cathode of V_1 positive with respect to ground, and an equal negative bias is applied to the plate of V_2. The only discharge path for C_4 is through R_1 and R_2 which have values of

10,000 to 15,000 ohms each. Therefore, the time constant is relatively long, and the voltage E_{C_4} remains constant.

As in the circuit of Figure 6, the voltage across capacitor C_4 in Figure 7 provides bias for the diodes. You can think of C_4 as being a battery which applies its voltage E_{C_4} to the series circuit consisting of V_1, L_3, L_4, and V_2. With no diode current, there is no direct voltage across the winding L_3L_4. Therefore the cathode of V_1 has the same voltage as the plate of V_2. This consideration simplifies the equivalent circuit to a battery of voltage E_{C_4} connected to two diodes in series. As the diodes are alike, half of E_{C_4} is across each tube. Since it connects to the negative terminal of C_4, the plate of V_1 is negative with respect to its cathode. Also, connected to the positive terminal of C_4, the cathode of V_2 is positive with respect to its plate. With a resistance of 15,000 to 25,000 ohms, R_1 is merely a discharge path for C_4 in this circuit.



The twin diode 6AL5 is employed as a ratio detector in the television receiver sound channel.

In both circuits of Figure 6 and Figure 7, the bias E_{C_4} prevents conduction of the diodes except during the short intervals when the i-f peaks exceed the bias. This arrangement tends to prevent undesired changes in i-f amplitude from effecting the conduction of the diodes. As a result, the diode conduction depends only upon the changes in the phase relationships of the various applied signal voltages E_{L_2}, E_{L_3}, and E_{L_4}.

A discriminator circuit employed in the sound channel of older model television receivers is the Foster Seely discriminator of Figure 8. Here, the plates of both diodes connect to the transformer secondary, and two capacitors, C_3 and C_4, connect in series from V_1 cathode to V_2 cathode. In this circuit, the voltage across L_1 and C_1 is coupled through C_6 to appear across L_2. As shown, L_2 also connects to the center point of the transformer secondary, so that voltages E_{L_2} and E_{L_3} are applied in series to V_1, and E_{L_2} and E_{L_4} are applied in series to V_2. As with the ratio detectors, the i-f carrier frequency variations cause corresponding phase shifts of E_{L_3} and E_{L_4} relative to E_{L_2}. Consequently, V_1 alternately conducts more and then less than V_2, with the difference proportional to the frequency deviation. The V_1 current pulses charge C_3, and the V_2 current pulses charge C_4. Due to the directions of these currents, E_{C_3} is positive and E_{C_4} negative with respect to ground.

At any instant, the algebraic sum of these two voltages is either positive or negative by some amount, depending upon which diode is conducting more heavily. Thus, the total voltage across C_3 and C_4 varies at the rate of the carrier frequency changes, and by an amount depending upon the magnitude of the deviations. This varying total voltage is the audio signal, and is coupled through the de-emphasis filter R_3C_5 to the input of the audio amplifier.

Gated Beam Detector

A gated beam detector circuit used in television receivers is shown in Figure 9. Here, tube V_1 is the type 6BN6, which has special electrode construction such that the electrons from the cathode are formed into a beam as they travel to the plate. Coupled through transformer L_1L_2, a large amplitude i-f voltage drives the limiter grid alternately to cutoff and saturation. This action produces pulses of beam current which form a periodically varying space charge in front of the second control grid, or quadrature grid, shown nearest the plate in the tube symbol of Figure 9.

By electric induction, an alternating current is produced in the quadrature grid circuit, which contains the tuned circuit L_3C_4. The coil and capacitor are tuned to resonance at the i-f center frequency, 4.5 mc. This current causes oscillations to occur at the resonant frequency, and a voltage is developed across the tuned circuit which lags the input voltage on the limiter grid by 90°.

#8

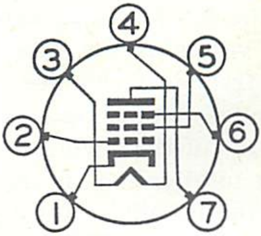
Whenever the voltage across the quadrature circuit makes the quadrature grid positive, it allows electrons to reach the plate, providing the limiter grid is positive also at this instant. Thus, the two grids act like a pair of gates. Plate current exists only during the short intervals that both gates are open. Since the driving voltages on the grids are out of phase, the plate current consists of pulses.

Following through the sequence for one cycle, we can begin with both grids negative—both gates closed. First the limiter grid becomes positive to open the first gate. Later, the quadrature grid becomes positive to open the second gate and allow plate current to start. Next, the limiter grid goes negative, ending the plate current pulse. Finally, the quadrature grid goes negative, to complete the cycle.

The duration of the plate current pulses depends upon the phase relationship of the voltages on the two grids. In the quadrature circuit, the oscillations remain constant at the resonant frequency of the circuit. Therefore, the voltage E_{L_3} on the quadrature grid is maintained at the center frequency of the i-f signal. As the i-f swings above and below the center frequency, the voltage E_{L_2} applied to the limiter grid shifts in phase with respect to E_{L_3}.

When the i-f swings above the center frequency, E_{L_2} leads E_{L_3} by more than 90°. The time that both gates are open is shorter, and the plate current pulses have shorter duration. With the i-f below the center frequency, E_{L_2} leads E_{L_3} by less than 90°, and the plate current pulses are longer because both gates are open over a longer period. The average plate current is proportional to the duration of these plate current pulses. The plate current charges capacitor C_5 to produce a voltage E_{C_5} which is proportional to the average plate current. Therefore, E_{C_5} is the output audio voltage, since it follows the variations in frequency of the i-f carrier.

BASING DIAGRAM



The 6BN6 is used as a gated beam detector. Sometimes, this sound channel stage is referred to as a quadrature detector.

In the plate circuit of V_1, the current pulses are at the frequency of the i-f carrier, and a voltage at this frequency is developed across the series resistor R_3. This voltage has the proper phase such that, when coupled to the quadrature circuit through the interelectrode capacitance of the plate and quadrature grid, it aids in driving this circuit. Since this interelectrode capacitance is also part of the tuning capacitance of the quadrature circuit, R_3 damps this circuit to suppress voltage variations due to undesired amplitude modulation of the signal.

In practical circuits, R_3 has a resistance of 500 to 1000 ohms. The capacitance of C_5 is selected such that R_3 and C_5 together form a de-emphasis filter.

Unless the tube is operated on the linear portion of its plate current-limiter grid characteristic, output noise may result due to undesirable amplitude modulation in the i-f carrier. The proper operating point is selected by means of the variable cathode resistor, R_1, called the BUZZ CONTROL.

SOUND CHANNEL AMPLIFIERS

At the output of the video detector or video amplifier, where it is separated from the video signal, the 4.5 mc sound i-f carrier does not have the amplitude required to properly drive the audio detector. Therefore, this carrier passes through at least one stage of amplification before the FM detector. Likewise, the audio output of the detector is not large enough to drive the loudspeaker properly. Thus, the receiver employs an audio amplifier of one or two stages, depending upon the type of detector used.

As radiated from the transmitting antenna, the sound carrier has practically constant amplitude. In other words, it has almost no amplitude modulation. However, as the signal is propagated through space, picked up by the receiving antenna, transmitted by the lead-in to the receiver, and passed through the various receiver circuits, it acquires a certain amount of amplitude modulation. If this modulation affects the audio detector, it may produce noise and distortion in the reproduced sound. To prevent these undesirable effects, the receiver circuits are designed to limit the amplitude of the i-f carrier to some maximum level.

The amplitude limiting action of capacitor C_4 in the ratio detector circuits of Figures 6 and 7 has been explained. Also mentioned was the fact that, by damping the quadrature LC circuit, resistor R_3 provided limiting in the gated beam detector of Figure 9. In addition to these methods, many receivers operate one sound i-f amplifier stage such that it provides an amplitude limited output.

In the television receiver sound channel, the sound i-f amplifier is a transformer-coupled radio-frequency amplifier with control grid and plate circuits tuned to resonance at the center frequency of 4.5 mc. The amplifier has a response which is flat over a frequency range broad enough to allow for the deviation of ±25 kc representing 100% modulation.

When the i-f amplifier is employed for amplitude limiting as well as amplification, the circuit is like that shown in Figure 10. The cathode resistor is omitted and grid leak bias employed. Also, low plate and/or screen voltages are used. With this design, the signal can easily drive the grid negative beyond cutoff, and to saturation during the positive peaks. Therefore, in normal operation, the plate current of the limiter varies from cutoff to saturation during every cycle of the i-f signal. As a result, the output of the stage has constant amplitude determined by the plate, screen, and control grid operating voltages.

Most receivers employ either one or two sound i-f stages. When there is one stage, it may operate as a conventional amplifier only; or as a limiter as explained above. With two stages, both may be amplifiers without limiting, or one may be a limiter. The limiter always is located just before the detector. When the sound channel employs a ratio detector, usually a two-stage audio amplifier is included.

The a-f voltage output of the detector is coupled to a voltage amplifier stage which increases the audio voltage to a sufficient level to drive the power amplifier. Usually, the gated beam type of detector provides a voltage output great enough to drive the power amplifier directly, and the a-f voltage amplifier stage is omitted.

SOUND CHANNEL CIRCUIT

With Ratio Detector

The sound section of a television receiver is given in Figure 11. Reviewing briefly, the sound i-f carrier is separated from the video signal at the output of V_1. Beginning at this point, the i-f carrier is amplified in the V_2 stage, and then demodulated in the ratio detector employing the twin-diode V_3. The a-f output of the detector is amplified by the voltage amplifier, V_4, increased in power by the output tube V_5, and coupled through transformer T_2 to the speaker.

In the particular sound channel illustrated in Figure 11, the i-f amplifier stage does not operate as a limiter. Cathode bias is employed, and the typical B+ voltage is applied through decoupling resistor R_4 to the V_2 screen grid, and, from this point, through L_4 to the V_2 plate. The output capacitance of V_2 and the primary winding L_4 form a parallel LC circuit which is tuned to resonance at 4.5 mc. A balanced ratio detector is employed, of the type explained for Figure 6. Here, capacitor C_8 is charged positive by one diode current and negative by the other to produce the audio voltage. R_9 and C_{11} form the deemphasis filter, from the output terminal of which the a-f signal is coupled through C_9 to the audio volume control R_8.

The a-f voltage amplifier tube is a twin diode, high-mu triode, but here the two diode plates are tied to the cathode and the tube is used as a triode.

The audio output tube V_5 is connected in a series-parallel arrangement with a number of other tubes in the receiver, as indicated at the right center of the diagram. The circuits are so designed that all tubes are supplied with the correct screen and plate voltages.

A point of particular interest is the method of biasing the grid of the output tube. With tube V_5 in series with other tubes in the plate voltage supply circuit, its cathode is at a relatively high positive potential with respect to ground.

To obtain the proper negative bias under these conditions, the grid must be made positive with respect to ground. For example, assume that in the circuit of Figure 11, B+ is 250 volts positive with respect to ground and the cathode of V_5 is 100 volts positive. For proper operation, the grid should be 8.5 volts negative with respect to the cathode, therefore it must be $100 - 8.5 = 91.5$ volts positive with respect to ground and B−.

In this table model television receiver, space for the large screen is obtained without increasing the cabinet size by locating the controls at the side.

Courtesy Trav-ler Radio Corp.

This potential is obtained by the voltage divider made up of resistors R_{13} and R_{14} connected across the 250 volt B supply. As the grid current is negligible, the voltages across the resistors are proportional to their resistance. The grid is connected to the junction between the resistors. Therefore the voltage across R_{14} should be 91.5 volts and that across R_{13}, $250-91.5=158.5$ volts.

To prevent interaction between the tubes in this series parallel arrangement, a filter circuit is used. The filter consists of capacitors C_{15} and C_{17} and resistor R_{15}.

The 6AS5 is a miniature beam power amplifier used in the output stage of the television receiver sound channel.
Courtesy Radio Corporation of America

With Gated Beam Detector

The sound channel circuits of another receiver are shown in Figure 12. Here, as explained, the sound i-f carrier is coupled by T_1 into the grid circuit of V_2, in the first stage of the sound channel. In this receiver, the V_2 stage is a limiter, and operates in the manner explained for Figure 10. The limiter output is coupled by T_2 to the input of V_3, a gated beam detector. The developed a-f voltage appears across load resistor R_9, and is coupled by C_{10} to the grid circuit of a-f output tube V_4. In this circuit, variable resistor R_{10} serves as the grid resistor for V_4 as well as the volume control for the receiver.

To supply a high plate voltage for V_3, R_9 connects to a B+ voltage of 435 volts. With this relatively high supply voltage, the V_3 stage produces a large signal voltage output across R_9. This a-f voltage is great enough to drive the output tube without the need for a voltage amplifier.

CAUSES OF DISTORTED SOUND

Some faults in a receiver result in an undesirable output sound generally known as "buzz". One of the most common causes of buzz is misalignment or misadjustment of some tuned circuit such that the picture i-f and sound i-f signals are not in the proper proportion at the input to the video detector. At this point, the sound i-f carrier should be only 3 to 5 per cent of the picture i-f signal amplitude. If it is greater than this, video signal modu-

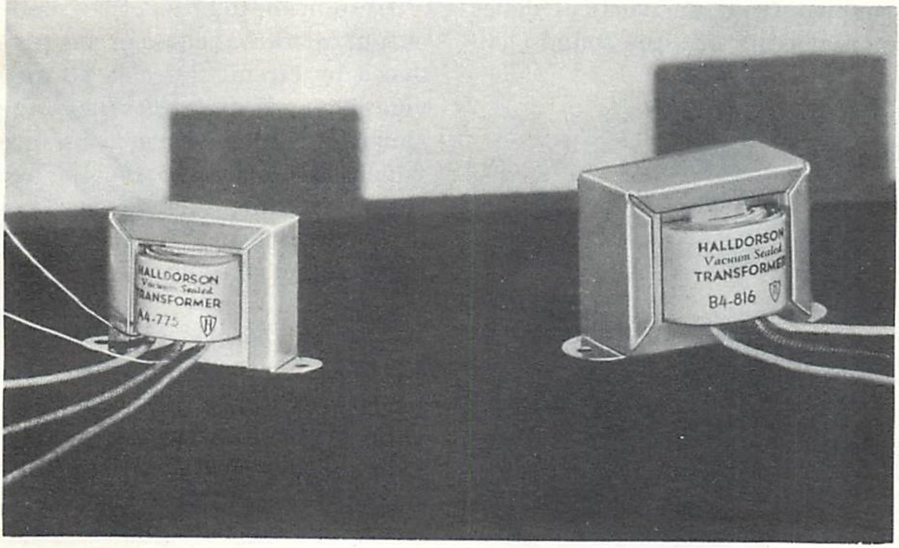
#10

lation of the sound i-f carrier may occur, and this modulation carried through the sound channel to be added to the regular audio signal.

Misadjustment of the fine tuning control can produce this effect. When this control is not set correctly, the oscillator frequency is incorrect, and the mixer produces an i-f band which is shifted up or down with respect to the band which the picture i-f circuits have been tuned to pass. Thus, these i-f circuits may have greater response to the sound i-f carrier than they should have, resulting in the improper relative signal strengths.

Misalignment of picture i-f tuned circuits is another cause of improper signal proportions, especially the tuned circuit just preceding the video detector. In many cases, careful adjustment of the coil slug in this circuit considerably reduces or eliminates the buzz.

A third source of buzz is mistuning in the sound i-f circuits. For example, if either the tuned circuit L_3C_3, the primary circuit of T_1, or the secondary circuit of T_1, in Figure 11, is misaligned, amplitude modulation may be detected by the ratio detector to produce buzz. Capacitor C_6 may change in value as the circuit



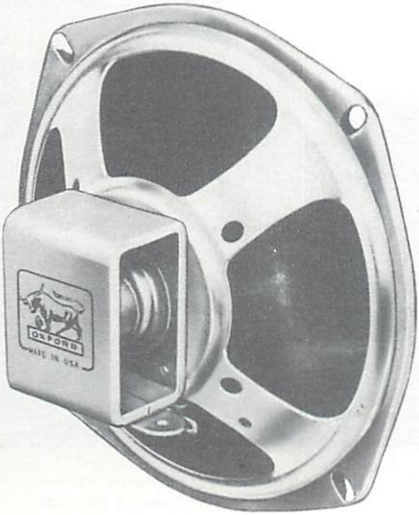
Audio output transformers. With many turns in the primary and few turns in the secondary, these transformers step up the a-f current output of the last sound channel stage to properly drive the loudspeaker.

Courtesy Halldorson Transformer Co.

warms, to detune the ratio detector transformer secondary circuit.

If either tube V_2 or V_3 is faulty, it may cause improper circuit operation resulting in buzz. Capacitor C_7 may decrease in capacitance, and thus be unable to limit properly any changes in i-f signal amplitude.

Buzz can be the result of energy coupled from the vertical deflection circuits into the sound channel circuits. This occurs when the wiring or some component of the deflection circuit is near the wiring or a component of the sound channel circuits so that magnetic or electric induction can take place. Or, it may happen as a result of insufficient filtering in the B supply circuits. Changing the setting of the vertical oscillator frequency control normally changes the pitch of the buzz if coupled from this circuit. This fact provides one means of checking to determine the source of the trouble.



Like the picture tube in the video section, the speaker converts the electric energy output of the sound channel to vibrations of air which convey the audio information to our ear.

Courtesy Oxford Electric Corp.

In addition to buzz, other sound output disturbances can be produced by circuit defects. To provide changes in resistance, the slider on R_8 moves over a surface which is normally smooth and clean. If this surface becomes dirty or uneven, it may cause noisy sound output.

Also, in the grid circuit of V_5, R_{13} and R_{14} must maintain the proper resistance ratio, since this ratio determines the bias on the grid relative to the cathode. For instance, should R_{14} increase in resistance, the voltage across this resistor will be a larger percentage of the B+ value. The grid then will be more positive. Depending upon the resistance change, the grid may have reduced bias, zero bias, or a positive bias. Any of these conditions will cause the amplifier tube to operate at a point other than the center of the linear portion of its characteristic and distort the signal.

Should C_{14} become shorted, R_{11} and R_{12} in series will be placed in parallel with R_{13} to reduce the resistance of this part of the voltage divider. In this event, both the plate of V_4 and control grid of V_5 will have incorrect operating voltages to produce a distorted sound output.

The sound take-off transformer, T_1 in Figure 12, has the main purpose of coupling the 4.5 mc i-f sound carrier to the sound channel. In addition, it should prevent the sound signal from getting to the picture tube, and keep the video signals out of the sound channel circuits. However, it may not perform this latter function well if its Q is not high enough, in which case video signals may pass through the sound circuits to produce buzz. If the sound i-f signal amplitude coupled by this transformer is low, it may not drive the limiter tube to saturation. Without proper limiting action, amplitude modulation may pass to the detector to cause noise or buzz in the output.

In the detector circuit, Figure 12, variable resistor R_6 is the buzz control, and is adjusted to provide the proper cathode bias for gated beam tube V_3. When the bias is not correct in this circuit, operation may occur on the curved portion of the plate current-grid voltage characteristic to produce a buzz.

In addition to separating the sound i-f carrier from the video signal, the television receiver must separate the synchronizing signals from the picture modulation and blanking pulse portion of the video signal. As explained in earlier lessons, the transmitter produces these synchronizing signals and impresses them onto the picture carrier along with the picture signals. The exact nature of the sync signals and their specific purposes are explained in the next lesson.

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STUDENT NOTES

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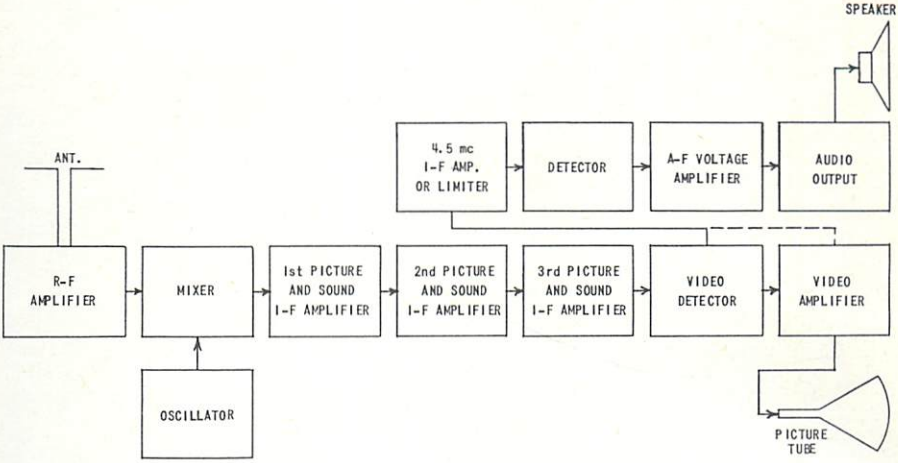

SPEAKER
ANT.
4.5 mc I-F AMP. OR LIMITER
DETECTOR
A-F VOLTAGE AMPLIFIER
AUDIO OUTPUT
R-F AMPLIFIER
MIXER
1st PICTURE AND SOUND I-F AMPLIFIER
2nd PICTURE AND SOUND I-F AMPLIFIER
3rd PICTURE AND SOUND I-F AMPLIFIER
VIDEO DETECTOR
VIDEO AMPLIFIER
OSCILLATOR
PICTURE TUBE

FIGURE 1

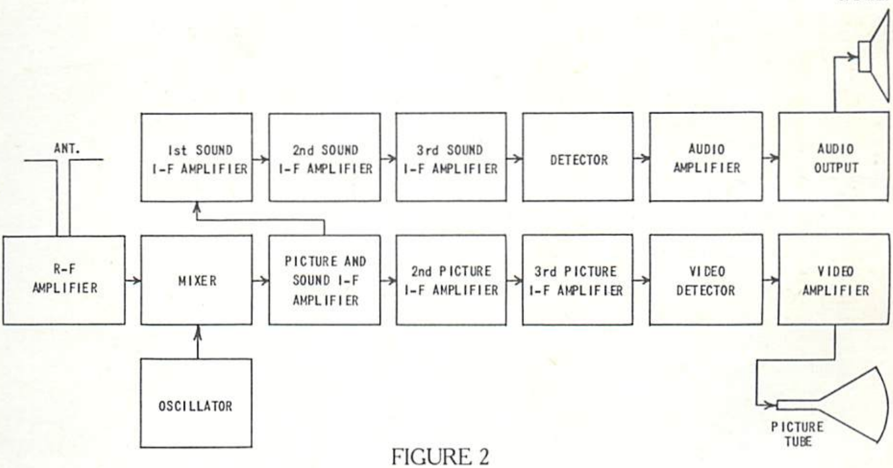
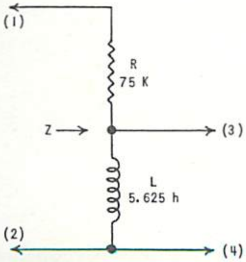


FIGURE 2



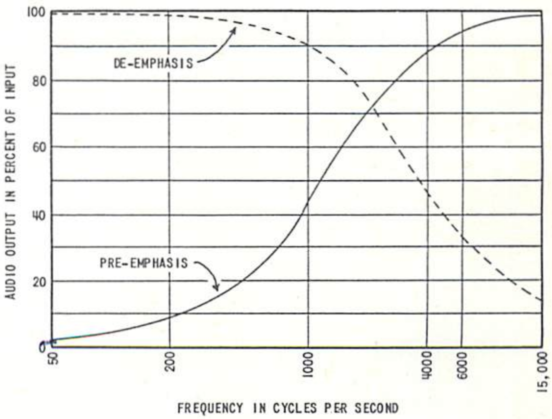


FIGURE 3

FIGURE 4

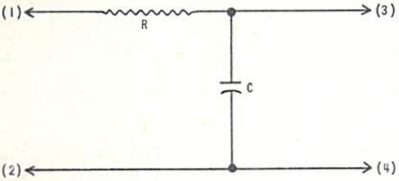


FIGURE 5

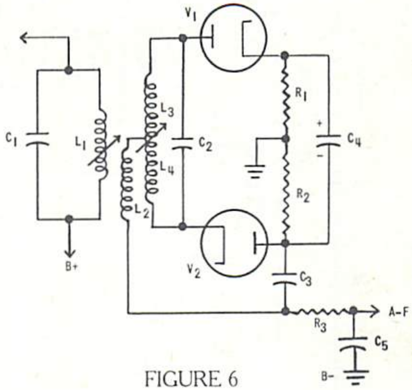


FIGURE 6

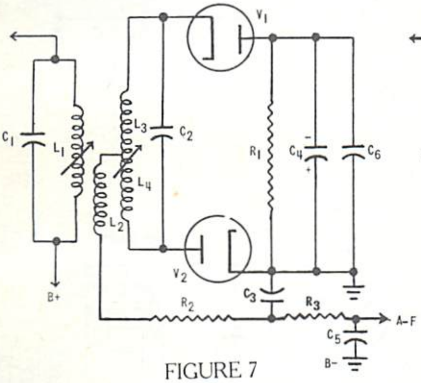


FIGURE 7

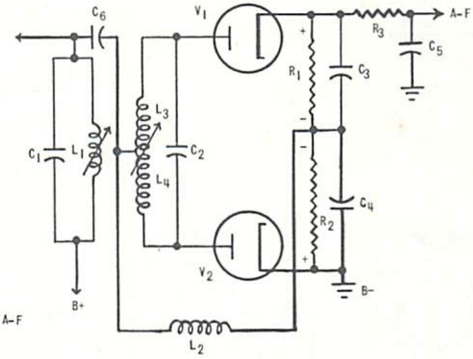


FIGURE 8

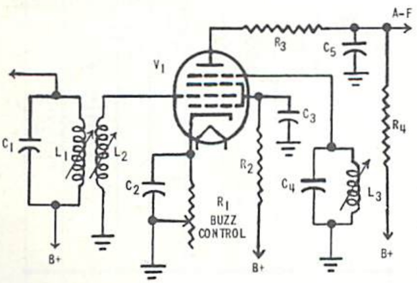


FIGURE 9

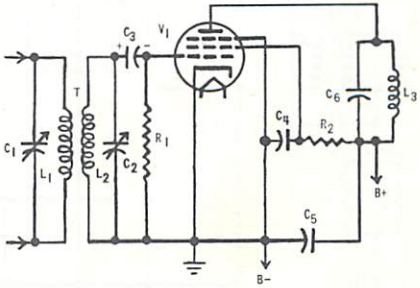


FIGURE 10

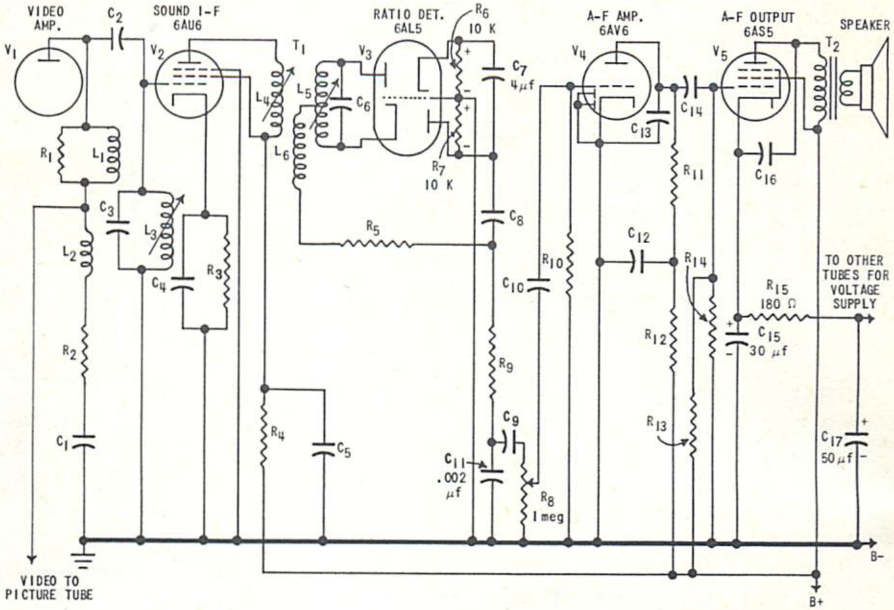


FIGURE 11

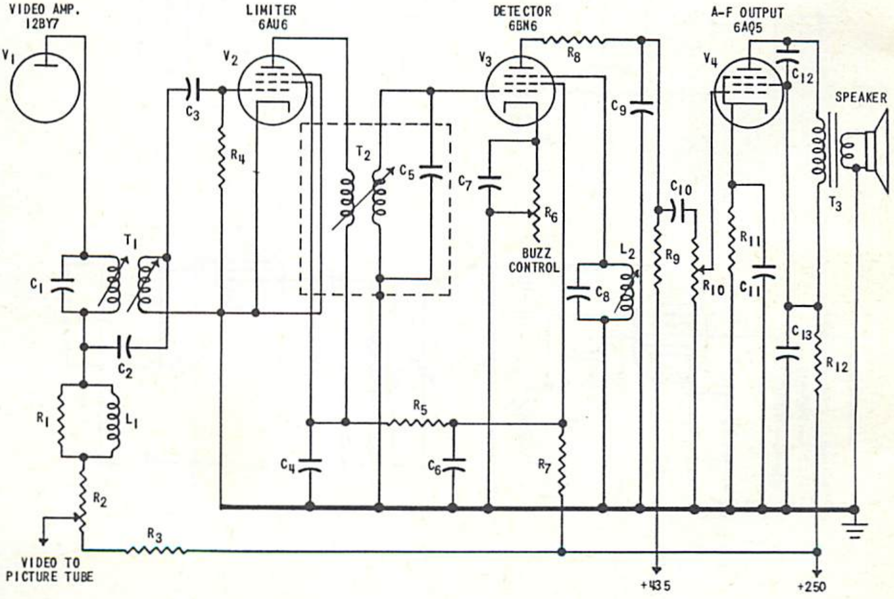


FIGURE 12

FROM OUR *Director's* NOTEBOOK

IDEAS AND PROGRESS

Progress depends on adaptability to changing circumstances. The species that adapts itself to changing conditions wins through and inherits the earth, or the sea or the air, as the case may be. The species that cannot change, that cannot adjust itself to new conditions, goes to the wall.

Today the world of business is full of change. Formerly a business might jog along in a narrow rut. Today, those ruts end in puddles of oblivion. Progress is essential. And progress springs from new ideas.

It is not sufficient today to satisfy the immediate needs of industry. We must anticipate those needs. And the successful men of today—the organizers, thinkers and creators—are the men who have schooled themselves to adapt their thinking to the changing horizons of business in order to visualize what industry wants before industry is conscious of its needs.

Yours for success,

W. C. De Vry

DIRECTOR

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